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THE IMPACT OF EMME/2 ON URBAN TRANSPORTATION PLANNING A PORTLAND CASE STUDY

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ABSTRACT

The impact of interactive graphics and an improved multimodal transportation planning software package on the urban transportation planning process and organization responsible for the planning is assessed. The focus is on the results of applying the new technology, which allows the planning organization to increase capacity to conceptualize and evaluate alternative courses of action. This emphases on the results of planning raises the likelihood of changes in the way transportation decision making occurs.

An advanced interactive graphics system for urban transportation planning process was adopted by the Metropolitan Service District (METRO) of Portland, Oregon, a Metropolitan Planning Organization (MPO). In September 1983, METRO's Transportation Planning Department acquired a state-of-the-art software program called EMME/2 (a bilingual acronym for Multimodal Equlibrium) which runs on a super microcomputer. EMME/2 is an interactive graphic method for highway and transit planning. This program aids transportation planning by graphically plotting, in a map format, detailed information about travel flows. It provides graphic display quickly to aid in the interpretation of heretofor voluminous amounts of difficult to assimilate data.

The new system is saving time and cost, but more importantly it is improving analysis by allowing more opportunity to interact with the results of analysis. It is also changing the character of work. The quicker turnaround time for analysis has created a demand for short-range studies, i.e. more traffic management applications. Finally, interorganizational impacts are

occurring. Other agencies in the region are becoming active users of the system.

INTRODUCTION

This investigation assesses the impact of interactive graphics and an improved multimodal transportation planning software package on the urban transportation planning process and the organization responsible for the planning. The focus is on the results of applying the new technology. which allows the planning organization to increase capacity to conceptualize and evaluate alternative courses of action. This capacity to analyze results of planning raises the likelihood of changes in the way transportation decision making occurs. Consequently, four types of impacts are analyzed:

* Technical planning applications involving the microcomputer system and its performance in comparison to the predecessor system particularly productivity gains in terms of time and cost of conducting transportation analyses;
* Staffing impacts in terms of a change in the mix of transportation planners and computer programmers;
* Organizational impacts, particularly changes in the flow of information and the nature of planning work;
* Political impacts, i.e., likely changes in the way decisions are made about transportation planning and projects.

This project derives from the adoption of an advanced interactive graphics system for urban transportation planning process at the Metropolitan Service District (METRO) of Portland, Oregon, a Metropolitan Planning Organization

(MPO). In September 1983, METRO's Transportation Planning Department acquired a state-of-the-art software program called EMME/2 (a bilingual acronym for Multimodal Equilibrium) which runs on a super microcomputer. EMME/2 is an interactive graphic method for highway and transit planning. This program aids transportation planning by graphically plotting, in a map format, detailed information about travel flows. It provides graphic display quickly to aid in the interpretation of heretofor voluminous amounts of difficult to assimilate data.

Organizationally, the new system was introduced to save computer cost and improve productivity. These cost and productivity changes have been dramatic and the manner of transportation planning has changed in response to the technology advance. This in turn may change the way transport decisions are made.

The study is divided into eight sections. The first is an overview of computer graphics in the field of transportation planning. The second section briefly describes the predecessor system, the Urban Transportation Planning System package (UTPS) and METRO's experience using it. The third section, provides a detailed description of the EMME/2 system and METRO's implementation experience with it. The fourth section presents a time and cost comparison of UTPS versus EMME/2. The fifth section identifies productivity gains. The sixth section describes impacts on transportation planning at METRO. The seventh section discusses interactions among the various impacts. Finally, conclusions are drawn concerning impacts of the new technology on the organizational environment of METRO and likely impacts on transportation decision making.

AN OVERVIEW OF COMPUTER GRAPHICS IN TRANSPORTATION PLANNING

An extensive bibliography on Applications of Computer Graphics in the Transportation/Land Use Field is available from the Council of Planning Librarians Bibliography Series No. 126 (1). Also, a special issue of Computers, Environment, and Urban Systems (2), and a Transportation Research Record (3) are devoted to interactive graphics applied to transportation.

Applications of computer graphics to transportation planning began in 1972. Two main types of applications have emerged: 1) mapping of primary transportation data or display of statistics derived from such data, and 2) computer-aided design, using graphic displays and maps to aid the interpretation of output from simulation models. Over the years, these applications have been used in the regional project and engineering design aspects of transportation planning. The remainder of this section briefly describes some of the key contributions as identified by Schneider (1).

An early mapping applications system, by Yehuda Gur (4), provided map displays derived from both existing and alternative future transportation systems. The Chicago Area Transportation Study, the Metropolitan Washington COG, and Tri-State Regional Planning Commission have used this system.

Several computer graphics programs for displaying origin-destination data have been developed. Typical of these are the Vector Accumulator Program developed at the University of Washington (5). It draws lines between each origin and destination in the metropolitan area and then accumulates them, with the width of the lines proportioned to the number of trips. Congestion levels, overall traffic patterns and transit trip patterns can be mapped with this system. Flograf was also developed at the University of Washington. This program can be used to display origin-destination data using color to represent the dynamics of commuter traffic through time.

With respect to Computer-Aided Design Systems, a series of short-range transit planning tools have been developed at the University of Washington, General Motors Transportation Systems Center (GMTSC), the AB Volvo Company in Sweden, the Comprehensive Planning Organization in San Diego and the University of Montreal. The first of these systems, the Interactive Graphic Transit Design System (IGTDS), was developed by Rapp (6) at the University of Washington. Tied directly to a simulation, it generated and evaluated several alternative many-to-one transit system designs, producing both graphic and tabular output. It contained a routine to detect errors in input data. Used extensively as an instructional tool at Cornell and the University of Washington, it has been applied in studies at Detroit, Michigan and Bellevue, Washington.

Another system that has been applied both in Europe and the United States is the Transit Network Optimization Program (7). This system is designed to work in a transit-only mode and functions in a many-to-many origin destination framework. One of the most advanced interactive graphic transit planning tool currently available in the United States, it has been applied in Chicago, Washington, D.C., Baltimore, Portland, Indianapolis and Seattle.

A recent entry and the primary interest of this study is the EMME/2 system developed by Michael Florian and others (8) at the University of Montreal.

EMME/2 has been applied in Stockholm and Winnipeg and is operational at the Metropolitan Services District in Portland, Oregon. This is the first interactive graphic multimodal microcomputer-based turnkey system that has reached the market place.

BRIEF DESCRIPTION OF THE UTPS SYSTEM AND METRO'S EXPERIENCE WITH IT

METRO, as has most MPO's, has been using the Urban Transportation Planning System (UTPS) for long-range regional transportation planning. UTPS was developed jointly by the Urban Mass Transportation Administration (UMTA) and the Federal Highway Administration (FHWA) (9, 10). The UTPS package runs on a mainframe computer, in batch mode and produces tabular output that must be posted on maps manually, or plotted by computer off-line. At the time it was developed, its batch operation and tabular output were typical, and UTPS was well regarded. However, the advent of interactive graphics has increased expectations of users considerably.

The package was originally designed for long-range planning, to help identify transit service levels and route alignments for growing urban areas. Subsequent additions to UTPS have made it possible to conduct short-term highway and transit studies.

UTPS consists of a number of programs which correspond to the standard transportation planning process of Trip Generation, Trip Distribution, Modal Split and Trip Assignment. Capabilities of the package include estimation of long-range land development impacts, transportation system costs, travel demand, major facility and corridor travel volumes, energy use, air pollution and traffic accidents.

Metro's Use of UTPS

METRO has used the UTPS package since 1976; it was installed on a metropolitan data processing authority's mainframe computer. It has been used extensively with computer charges alone exceeding $60,000 per year.

The management and use of UTPS at Metro have required three planners full-time. Their repertoire included working knowledge of the Job Control Language (JCL), UTPS inputs, analytical reports and designing studies with the UTPS package. They had to be knowledgeable in both computer programming and transportation planning.

The UTPS package is generally considered in this era of user friendliness as data hungry, slow to respond, labor intensive, requiring a high level of technical skill, and very expensive in terms of computer time. The output of a UTPS analysis is in the form of matrices, trip tables and line reports. It is not interpretable until transferred to a node-link or network map. This is done by hand posting the output on a network map, which can be tedious and time consuming or by an off line plotter. Metro's experience with the assignment package was that it required significant "smoothing" by hand, which limited the utility of acquiring a plotter and driver software. Nor could transit link loadings be plotted as the output was by line, not link. This led Metro to rely on hand posting of assignment output to network maps. This posting process makes the UTPS package and its use prone to error. On the whole, it is an labor intensive package particularly in the input and output stage, and is in the process of being displaced by more advanced systems.

Perhaps the driving force for displacing UTPS is cost. Operation on a mainframe computer was proving costly to METRO. UTPS was costing in excess of $100,000 per year, which included personnel computer and data collection costs. These UTPS applications include network and model improvements, major study costs, individual analysis costs, and computer charges. The network and model improvements activities include coding highway or transit networks, data collection, and development of mathematical models that predict future travel patterns.

Major study costs could amount to $80,000 a year. This rough estimate includes the cost of model development, data collection, and staff and computer time. Individual analysis costs can vary from $200 to $1,000. It is the computer costs which turn out to be the biggest repeating cost of using the UTPS, this being reflected in METRO's annual computer budget which ranged from $50,000 to $60,000 (it has been as high as $80,000 during years of major studies).

METRO had the option of replacing UTPS or updating it. They could have stayed with UTPS by coding a more detailed network, installation of a plotter, and a more efficient assignment algorithm. They chose not to however, because these improvements would not solve all the perceived problems of UTPS. UTPS would still be deficient in the following areas: 1) dependence on the user unfriendly JCL to manipulate the system, 2) no network editing software, 3) merely plotting volumes would be insufficient, 4) larger system of zones would require more computer time, and 5) an expensive mainframe computer would still be required.

The EMME/2 SYSTEM: A BRIEF DESCRIPTION

Equilibre Multimodal/Multimodal Equibrium, (EMME/2) is a multi-mode urban transportation planning technique designed by M. Florian and others at the Transportation Research Center, University of Montreal, Canada. EMME/2 was initially implemented on the Pixel 100/AP Supermicro, a 32-bit, multi-user, 68000-based computer that supports the UNIX operating system. It is now available on the DEC VAX computers, Sun Workstations, the Masscomp MC 1500 and will soon be available on other machines, such as the AT & T UNIX based PC and the Tektronix 6000 series of workstations.

Underlying Concepts of EMME/2 System

EMME/2 combines a zonal aggregate demand model (which may be a direct demand model or an O-D table coupled with a suitable modal split function) with an equilibrium type road assignment and transit assignment method. This planning technique has been implemented in an interactive environment. The approach uses interactive graphics to enable direct dialog with real time graphic or non-graphic response, between the planner and the computer based planning method (EMME/2). It aids the planner by using familiar terminology with a menu-driven software that obviates data processing type tasks. With the data base set up, the planner need not be concerned with the technical details of computer programming or computer systems. It permits the instantaneous visualization of input data, results of computations and information retrieved from the data base, all in graphic or list form. The EMME/2 system is a comprehensive interactive graphic transportation planning method.

Data Base

The transportation system consisting of user demand and facility supply is depicted in a data base. Data may be entered, modified and used for calculations in EMME/2 in three forms: 1) networks, 2) matrices, and 3) functions. Figure 1 is a schematic representation of the EMME/2 data base.

Networks. The transportation infrastructure of the urban region is represented by a multi-modal network of links representing the streets and transitways, and nodes representing the intersections. The base network is defined by the list of all nodes and all links between those nodes, used by any of the modes. Networks may be modified provided that the hierarchy of the data structure is respected (e.g., a transit line cannot use a vehicle type not present in the vehicle table). Figure 2 describes the network structure.

Transit lines are defined as a sequence of nodes. It is not necessary to specify all the nodes along a route. If nodes are omitted, the line is assumed to pass through the nodes on the shortest path between the specified nodes. Dwell time and the transit time function, which correlates the speed of the transit line to that of the auto mode, need only be specified when their value changes. These parameters are stored as variables for line segments.

The planner may specify up to three additional data elements for each node

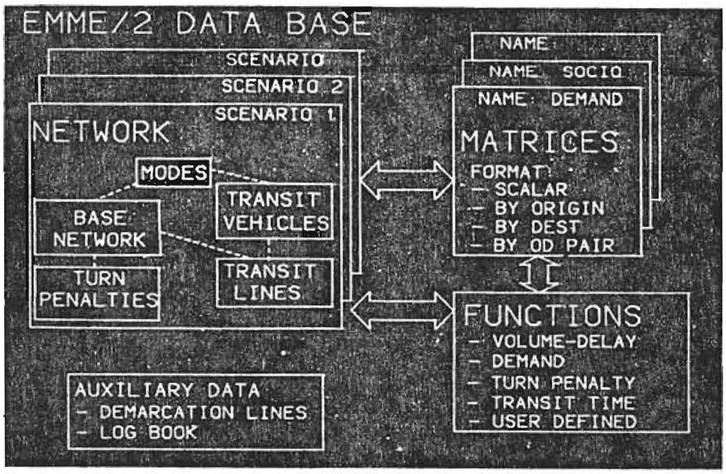

FIGURE 1: EMME/2 DATA BASE

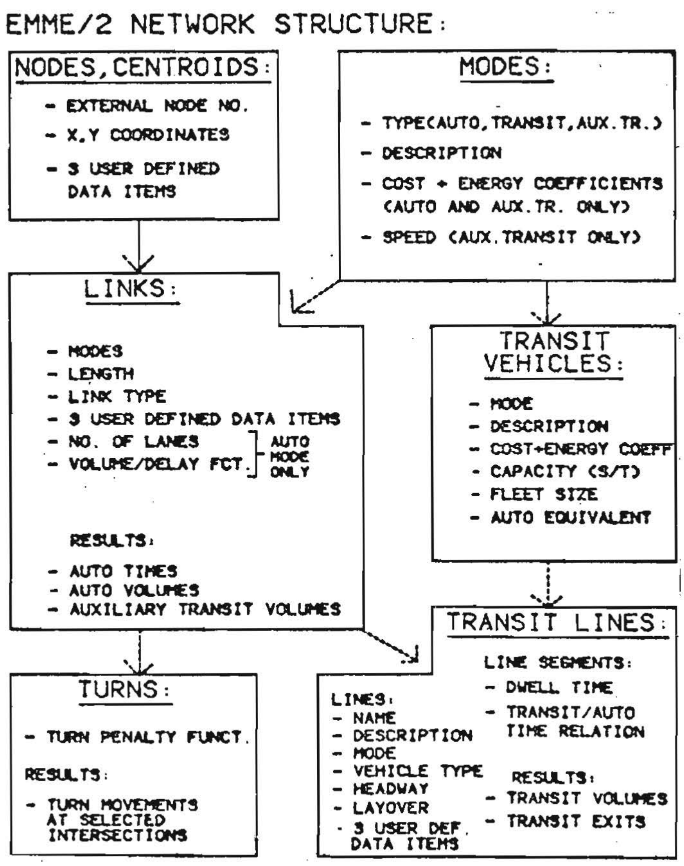

FIGURE 2: EMME/2 NETWORK STRUCTURE

Source: EMME/2 - User Oriented Materials and Documentation.

link and transit line. Such "user data" may include observed-link flows, observed-link travel times, for comparison to model estimated values.

Each complete network data set, i.e., modes, base network, transit vehicles, turn penalties and transit lines, make up a scenario, and the base year is one of these scenarios. The user may define a new scenario, by duplicating the data present in any existing scenario and making the appropriate changes in any one of the network data components. All these manipulations may be performed interactively, with graphic output if desired.

Matrices. The matrices that are handled in EMME/2 may be full matrices, vectors or scalars. These may contain a vector of socio-economic data related to the zones of the urban area studied, origin/destination traffic flow and travel times by mode.

The matrix editor is designed to permit the planners to choose a matrix format appropriate to the data. For example, the traffic assignment routine requires an origin/destination matrix. The planner must create or define a matrix to contain the correct data for the analysis desired. This provides flexibility in evaluating a given scenario with different O/D matrices, such as a.m. peak flows, p.m. flows, etc.

Functions. All functions that are used in EMME/2, such as volume/delay functions, transit/auto travel time relationships, turn penalties and demand functions are specified by the planner as algebraic expressions. When an EMME/2 module requires the use of a particular function, the function is then evaluated by using the appropriate data that corresponds to the variables specified by the user in the algebraic expressions that define these functions.

Results

Multi-modal equilibrium assignment is the strong feature of EMME/2 . It computes the equilibrium demands, flows and service levels for all the modes considered.

EMME/2 permits the user to obtain a wide variety of results, both in interactive graphic form and/or as printed output. The main feature of the results is interactive comparison of scenarios with accompanying graphic display. While the main results pertaining to comparison of scenarios are related to link flows, O/D demands and service levels, a wide variety of other results may be obtained using the user defined data.

Unlike a "batch" environment, where each successful execution terminates with a particular set of results, an interactive graphic environment permits the user to obtain results of different types during a particular EMME/2 session. The notion of "result" is thus different from that of a batch environment and may be considered to consist of the entire gamut of results of computational procedures, data bank queries and scenario comparisons.

The technology is providing more than greater productivity in performing the same function. The results differ substantially, the products of EMME/2 are different than the UTPS products.

Implementation Experience with the EMME/2 System

Interaction allows the planner a dialog with the data add models, and graphics allows the visualization of the output and enables a quick assessment of reasonableness.

METRO acquired the transportation planning software EMME/2 and the PIXEL 100/AP supermicro in late August 1983. Initially the system was run in parallel with the continuing use of the UTPS package.

A systems programmer was assigned full-time to implement the system and to become familiar with the functions of the host computer, i.e., the PIXEL. While this was in progress, transportation planners were creating a new base network for the Portland urban region. This was done by digitizing network nodes and zonal centroids from a base map, and some downloading the UTPS network.

Due to budget limitations using UTPS, the region was divided into separate networks for an Eastside subarea and a Westside subarea. This approach works well with the size limitations for practical run times on the PIXEL and was continued. The so-called 1980 Eastside database in the EMME/2 is a complete network for the region consisting of a base network of 381 zones, 2,031 nodes and 6,842 links. This 1980 Eastside Scenario is detailed on the Eastside of the region and sketchy on the Westside of the region. It is complete in all respects, i.e. it has a transit network as well as a highway network in place. During an assignment procedure, EMME/2 calculates the mileage and time, compares street volumes to capacity, and builds a network of optimal travel paths. The final result is a computer map of volumes on routes.

Stage 1

The preparation of trip tables and matrix manipulation would continue to be carried out on UTPS, while trip assignment and analysis of results would be carried out on EMME/2. Because UTPS is weak in display of assignment results, this function was moved first.

Stage 2

Transfer, trip generation, trip distribution, and modal split to the EMME/2, including trip table preparations, matrix manipulation, and re-calibration of the network system.

Stage 2 is complete; all these procedures have been successfully transferred to the EMME/2, UNIX based environment. The data manager of EMME/2 is proving to be more efficient for the preparation and analysis of scenarios in comparison to the JCL management of files in UTPS.

EMME/2 System - Cost Summary:

The cost of the initial system purchased by Metro is shown in Table 1.

Operating costs associated with the system include the maintenance contracts and wages for data processing system support. Cost of hardware and software maintenance for the PIXEL/Tektronix/EMME/2 system, is $12,000 per year. Cost of systems programmer support was $18,000. Supplies and materials added $3,000 for a total of $33,000 annually for maintenance.

A comparison of METRO's prior computer costs and those associated with the EMME/2 - PIXEL system illustrate the cost advantage of the new technology. In the past, Metro has spent $50,000 to $70,000 per year in computer CPU and print charges, alone. The initial cost (PIXEL microcomputer, operating system, EMME/2 software, one graphic terminal, four non-graphic terminals, hardcopy unit), if amortized over three years, plus the maintenance cost, is less than the annual cost of computer time using UTPS. Analysis of productivity gains requires a comparison of applications of UTPS and EMME/2.

COMPARISON OF UTPS AND EMME/2:

The network form of EMME/2 is almost identical to that of the UTPS (in terms of nodes, links, link attributes, line description, etc.), but EMME/2 has an effective data base manager, which increases productivity by reducing the time to link computerized elements of an analysis. Also, its assignment procedure has an efficient algorithm. The system is fully interactive and gives the planner the ability to build and edit networks, using a graphics terminal. EMME/2 allows planners to quickly develop comparative graphic output of senarios, which makes for an effective tool for the development and evaluation of alternatives.

The following discussion is a comparison of planning tasks carried out on the UTPS and EMME/2 system. It amply illustrates a savings in cost and time. Particularly, EMME/2 is more efficient than UTPS in building networks and updating networks, and is much more efficient for display and evaluation of alternatives.

TABLE 1

COST OF THE INITIAL SYSTEM

1.	Software for transportation planning and and general use (includes EMME/2, spread sheet, statistics package and programming languages).	$ 20,000
2.	PIXEL 100/AP microcomputer and its associated peripherals (includes the PIXEL, a Visual 500 screen, four non-graphic terminals, printer, etc.).	51,000
3.	Tektronix graphics hardware (includes the 4114A graphic terminal, digitizing board, 4663 plotter, 4611 hardcopy unit).*	39,000
	Total System Cost (Based on March, 1984, retail cost listing)	$110,000

* It is now possible to get usable graphics for a lower cost. Now graphics terminals, such as the Pericom (1000 x 800 pixels) are available for approximately $2,500 and the EMME/2 package can output hardcopy to dot matrix printers.

This discussion of comparative time and cost is based on a model system that has the following characteristics:

* Network Parameters

  8000 one-way links, 2500 nodes, 390 zones

* Computing Environment

  With UTPS, METRO was a remote user to an Amdahl mainframe. All printing was done remotely with results delivered daily. Initially METRO installed EMME/2 on a Pixel 100 A/P in-house, super-micro. All printing and plotting are now done locally

Table 2 provides a comparison of time to conduct tasks of updating auto links and transit lines using UTPS verses EMME/2. Interactive graphics speeds the update process significantly. Table 2 also shows the comparison of assignment and plotting of results. The graphic output of EMME/2 produces significant savings here.

A comparison of cost for updating and assignment is provided in Table 3. Savings result in both personnel and computer categories. Cost comparisons for typical studies are shown in Table 4.

Yet these time and cost comparisons do not capture the advantage of EMME/2 over UTPS. Currently, the ease of generating scenario <u>and</u> the ability to display the results in a variety of ways produces more carefully analyzed and thought through plans. Before the time and cost of analysis of a single alternative exhausted the time and budget and too little time was devoted to careful examination.

TABLE 2

TASK TIME COMPARISONS
(person-hours)

Update 100 auto links

Task	UTPS	EMME/2
Define link attributes	½ hr	½ hr
Code links	1½ hrs	
Data entry	1 hr	
Run software to update HR	½ hr	1 hr*
Review computer run - identify errors	½ hr	
	4 hrs	1½ hrs

Update 10 transit lines

Task	UTPS	EMME/2
Define line attributes - itineraries	1 hr	1 hr
Code lines	1 hr	
Data Entry	½ hr	
Run software to update transit files	½ hr	1½ hrs*
Review computer run - identify errors	1 hr	
	4 hrs	2½ hrs

Run assignment - Post/Plot 500 links

Task	UTPS	EMME/2
Prepare/submit assignment	¼ hr	¼ hr
Post links	2 hrs (by hand)	**
Determine differences from previous assignments	1 hr	
	3¼ hrs	¼ hr

* interactive graphics allows these tasks to be completed simultaneously

** graphic outputs (i.e., volume, plots, bandwidths, time, contours, comparison plots) are available to the user at the completion of the assignment.

NOTE: Computer run times will vary depending on the environment. Metro experience: 7 iteration assignment on Amdahl (15 min); 10 iteration on Masscomp (7 hrs). This difference in run time was negated by the once a day print deliveries. In addition, a wide variety of result data is graphically available to the user at the conclusion of the assignment.

PRODUCTIVITY GAINS

THe EMME/2 PIXEL system has proven to be extremely cost-effective. This combination has resulted in more than halving the computer costs to METRO in comparison to the UTPS system. In terms of staff productivity, METRO has estimated that there has been a four-fold increase. This increase results primarily from the time saved in results analysis i.e. the analysis and evaluation phase of a study. Thus the primary benefit of EMME/2 has been due to the increased ability to analyze the results of a scenario. This has allowed for new types of analyses, particularly short-range planning where quicker turn around is more crucial.

Assessing productivity is elusive. METRO is doing more work on EMME/2 than on UTPS; not just doing the same work more efficiently. They have encountered a new demand, a latent demand for micro or short-range traffic analysis, whereas, the UTPS long turn around time preluded responsiveness to short-range planning questions. Similarly, the coarse network inhibited response to micro-level traffic management questions. This ability to respond to short-range, more micro-level traffic analysis questions has heightened expectations. This demand has grown faster than the staff or system can respond. This demand was not adequately foreseen. Consequently, METRO is in the position of having to say no to requests. This has resulted in the following types of accomodations:

* METRO has devoted more staff resouces to short-range planning at the expense of long-range planning.
* Other agencies are acquiring terminals (Tri-Met and ODOT) or

TABLE 3

TASK COST COMPARISONS

Task	UTPS	EMME/2/PIXEL
Update 100 links		
Personnel	4 hrs/$100	1½ hrs/$40
Computer	$ 30	$20
	$130	$60
Update 10 transit lines		
Personnel	4 hrs/$100	2½ hrs/$60
Computer	$ 30	$30
	$130	$90
Run assignment-Plot 500 links		
Personnel	3¼ hrs/$80	¼ hr/$ 5
Computer	$200	$80
	$280	$85

NOTE: Personnel costs = $25 per hour
Computer costs
Mainframe = 34¢ per cpu second (1984)
Pixel = $200/day

TABLE 4

TYPICAL STUDY COSTS*

I. Determine impact of alternative street networks (e.g. Banfield ramp analysis)

Tasks required	UTPS	EMME/2
1. Develop 3 alternatives: 30 links changed in each scenario.		
Personnel	$ 90	$ 40
Computer	$ 30	$ 20
2. Assign trip tables to the 3 alternative networks		
Personnel	$ 240	$ 15
Computer	$ 600	$ 240
TOTAL		
Personnel	$ 330	$ 55
Computer	$ 630	$ 260
	$ 960	$ 315

II. Update a Regional Transportation Plan

	UTPS	EMME/2
1. Develop 3 alternative street networks - 300 links changed in each scenario.		
Personnel	$ 900	$ 360
Computer	$ 270	$ 180
2. Develop 3 alternative transit networks - 30 links changed in each scenario.		
Personnel	$ 900	$ 540
Computer	$ 270	$ 270*
3. Develop 3 alternative trip tables.		
Personnel	$1,500	$1,500
Computer	$ 600	$ 600*
4. Assign trip tables to 3 alternative networks.		
Personnel	$ 240	$ 15
Computer	$ 600	$ 240
TOTAL		
Personnel	$3,540	$2,415
Computer	$1,740	$1,290
	$5,280	$3,705

* Costs include only those tasks which are necessary to develop and prepare data for analysis. No analysis time is included. The EMME/2 costs are based on the PIXEL computer, not the new Masscomp.

buying the system to install on their own premises (City of Portland).

* METRO has had to acquire a new more powerful CPU, much earlier than anticipated.

IMPACT OF EMME/2 ON TRANSPORTATION PLANNING FUNCTIONS AT METRO

Two types of impact will be discussed here:

* Impact that EMME/2 has on the transportation planners, and
* Impact that EMME/2 has on the organization.

Impact on Transportation Planners

The first signs of EMME/2's influence on METRO's transportation planners is beginning to surface. In its first 18 months of operation, the system has impacted the planning staff, significantly. The nature of impacts is limited by the types of tasks and analyses that have been conducted to this point in time, however.

EMME/2 has impacted METRO planners in the following manner:

* planners do not need as much knowledge of computer programming or Job Control Language (JCL). Only one person needs to be proficient with the UNIX operating system, whereas UTPS required users to be JCL proficient. EMME/2 users need only to be 10 percent UNIX proficient.
* It takes less to acquaint planners with the basic operations of EMME/2, whereas UTPS familiarization required a minimum

period of 4 to 6 months. This is due to the user friendly menu-driven software, which makes the system available to more planners, more quickly;

* the planner is able to prepare scenarios, check for errors, obtain a visual plot on the screen, and final results in a hard copy all in a single interaction. This is much easier and provides more time to analyze the results;
* reducing uncertainty and time delays in computer utilization, data handling and error checking;
* no more manual posting of numbers on a network map from a stack of printout;
* the ability to be involved in a dialog with the system, observe the various stages of the scenario build-up and most important of all the freedom to maneuver within the modules of the system, gives the planner a feeling of being in control (not a slave to the computer) and adds a personal element to the task.
* User friendliness may be dangerous if planners are lulled by ease of use to exceed their knowledge of the travel demand and analysis models embedded in the system. Planners must be acquainted with the models -- their capabilities and limitations -- so as not to misuse them. An example is the knowledge and skill needed to determine when the potential impact of a shopping center should be assessed by factoring the productions and attractions of the impacted zones or by redistributing trips.

Organizational Impacts

EMME/2 has impacted the organization of METRO in the following ways:

* has lead to the increased use of the results and a greater dissemination of the information generated by the system;
* increased visibility has brought about increased public and technical scrutiny of all travel forecasts;
* has opened the planning process for inspection. The UTPS is a closed system, and the internal workings of the model are a "black box", the EMME/2 system is more of a "glass box", than UTPS, it displays not only output and results, but also the internal workings of the model;
* more use of interactive graphics as a communication tool for the creation and presentation of travel forecasts provides for a more effective communication of results of analyses;
* the ease of editing networks and comparing scenarios in a shorter period of time has increased the time for analyzing results, thereby, improving the productivity and quality of work from the transportation planning and engineering staff;
* the system has resulted in a shift in the skills needed at METRO from computer programming to transportation analysis;
* the system is generating a demand for more analysis and consequently more resources to buy more computing power. the initial system was quickly overloaded by the growth in demand.

Microcomputer technology coupled with interactive graphics has led to a change in the type and nature of planning work being done at METRO. Before the implementation of the EMME/2 system, METRO's primary task was the preparation of long-range regional transportation plans, with very little time available for short-range planning. Now, long-range planning is more productive, releasing valuable time which can be devoted to important short-term planning tasks, such as providing graphic answers to the perennial planning question, "What if we close this ramp or street?"

Word has spread rapidly within the region about EMME/2's capabilities, and METRO's transportation department has received numerous requests from various jurisdictions and businesses in the metropolitan region. The transit agency, Tri-Met, needed information to determine accessibility of bus service to minorities. The Oregon Department of Transportation needed to know what would happen to nearby streets with various ramps and bridge closures during the Banfield Light Rail construction. All this information was provided by EMME/2 in a shorter period of time, with lower cost and higher accuracy than would be the case with the UTPS. Other short-range projects carried out with the EMME/2 are traffic analysis for direct input with Environmental Impact Statements, analysis of neighborhood traffic issues and an assortment of traffic engineering projects. These demands are overloading the system and capacity has been reached. More computer power, more disk space, and more work stations are being acquired.

INTERACTIONS AMONG IMPACTS

The productivity gains are difficult to measure, because the results differ substantially. Nevertheless, productivity gains impact staffing requirements for transportation planning and the organization by increasing the demand for more and new kinds of analyses. This demand for more analysis is resulting in demand for expanding the capacity of the computer system. The cost of this expansion must be paid for from additional revenue from the new applications.

This increasing interest in the new planning tool and the more powerful results are leading agencies to buy into the system for their own use. This may lead to increased competition among agencies for advocacy results. This may lead to new ways for technical analyses to influence the way transportation decisions are made.

Interactive graphics and interactive data management removes the time and expertise barrier that for many years made transportation planning a black box process. A broader range of planners can exercise systems, such as EMME/2, and obtain useful results in a timely, cost-effective manner. In addition, these results are easy to interpret and revise if necessary. The increased ease with which to conceptualize and evaluate transportation alternatives is altering transportation planning significantly.

CONCLUSION

Conclusions derived from this exploratory study are preliminary, based on early implementation experience. It has been demonstrated, however, that microcomputer technology in the form of EMME/2/PIXEL 100/AP has had a significant impact on METRO's Transportation Planning Department. Most important of all is the new role for METRO in the region, i.e., from a predominantly long-range regional planning agency to one having a considerable amount of short-range transportation planning responsibility. This short-range planning is in the areas of transit planning, traffic management and highway construction management.

There has been a shift in skills needed for planners at METRO. The planner is no longer a slave to the computer as was the case with the UTPS, but more of a user with a sense of being in control of the working environment. The planners emphasis is on analysis, rather than computer programming, preparing input, or posting numbers of maps.

Another major impact is the increased productivity of the transportation planning department coupled with lower computer costs and a qualitative upgrading of analysis capability. There is also an increased dissemination of information to other agencies in the region. Interactive graphics provides valid and timely information that they find useful. The ability to display results in a variety of ways produces more carefully analysed plans.

An important aspect of this technology that may arise in the future which could impact METRO in a major way, could come from the agency's control over the flow of information or lack of control over information. The advantage to greater dispersion of information is a more open decision-making process. On the other hand, there is the danger of other jurisdictions or groups tapping into the system and developing alternative scenarios for a competing analysis of a controversial project. With UTPS Metro controlled the flow of information. With EMME/2 some of this control is lost and other agencies have access to analysis capability. Nevertheless, the tremendous economical and technical advantages this state-of-the-art technology has provided to METRO, presently far exceeds the threat of loss of information and analysis control. METRO still has the advantage in terms of expertise. Other agencies have not made sufficient commitment of resources to contest METRO on any analysis issue. As long as they feel adequately served by METRO, they will not likely commit sufficient resources to compete.

The effects of the organization impacts discussed above are difficult to estimate. Two quite different possibilities were identified at the Workshop on Interactive Graphics for Transportation Planners at Portland, Oregon in 1984 (13). Jerry Schneider anticipated a struggle for the information from the new technology:

> "There is fierce competition among cities for access to quality information and this is part of the politicization of the process." "Experience ... has shown that with increased dispersal of quality information comes an increase in the potential for stalemates."

Michael Florian responded:

> "It is easy to take a technological improvement out of context. It is quite possible that the political process as a whole will not be affected by the adoption of new technology. Technology is not responsible for stalemates, people are."

In the case of transportation planning in Portland, METRO will likely lose some control over analysis and information, temporarily. Other agencies are using that system and data. Their willingness to let METRO control the process is questionable. The time and cost to these other jurisdictions to undertake competing analysis is potentially less, if they see it in their interest to invest in using the system. If they do, their initial use will be to reassign traffic to variations of networks. As they gain more experience and sophistication they will develop scenarios that vary more fundamental factors such as density, work locations, modes, trip frequencies, etc. With more fundamental differences among scenarios, transportation decision makers will again be faced with completing analysis based on different data and assumptions.

To avoid this problem of competing analyses, or dueling scenarios, a policy is being formulated for the management and coordination of travel forecasts. This policy provides a framework within which amendments to the RTP and TIP, and federally funded project designs would be analyzed. The intent of such a policy should be to establish a base case forecast of populations and employment that all parties must use as a point of departure. Then organizations should be encouraged and assisted to create scenarios to analyze what-if questions. The policy should not attempt to impose technical regulations to legitimate transportation and land use policy questions, though.

EMME/2 is proving to be a technology advancement of a sufficient degree that the transportation planning process in the Portland area itself has been impacted. Organizations involved in the process are having to change the way in which they function and relate.

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